Connecticut River Basin
Supplemental Flood Management Study

land use changes in selected flood plains

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CONNECTICUT RIVER BASIN SUPPLEMENTAL STUDY

NEW HAMPSHIRE, VERMONT, MASSACHUSETTS AND CONNECTICUT

THE RIVER'S REACH

Phase II - LAND USE CHANGES IN SELECTED FLOOD PLAINS

UNITED STATES DEPARTMENT OF AGRICULTURE

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PREFACE

The purpose of this report is to examine the land-use changes with particular emphasis on agriculture that have occurred in the flood plain of the Connecticut River and two of its tributaries over a twenty-year period. This examination was confined to the Massachusetts portion of the Connecticut River Basin, thereby permitting the use of information developed for the Massachusetts Water Resources Study.

In addition to examining past land-use changes within the flood plains of the Connecticut, Mill, and Westfield Rivers, the probable effects of alternative flood plain management techniques on agricultural land were also considered. The alternatives included those identified in the Connecticut River Basin Supplemental Study. The budgetary allocation to this segment of the study severely limited the depth and detail to which it could be pursued. As a result, it is necessary to examine the impacts of proposed flood management alternatives on agriculture rather subjectively.

This report represents Part II of the United States Department of Agriculture's contribution to Phase II of the Connecticut River Basin Supplemental Study. Part I entitled An Analysis of Alternative Flood Management Plans in Upstream Watersheds was prepared by the Soil Conservation Service. More specifically, this is the input of the Economic Research Service to Task 2.1B of the New England River Basin Commission's "Plan of Study" for the Supplemental Flood Management Study of the Connecticut River Basin.

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LAND USE CHANGES IN SELECTED FLOOD PLAINS

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INTRODUCTION

Land use in flood-prone areas has particular relevance to water resource planning. Development within flood plains not only increases potential damages locally but also tends to reduce the natural storage capacities of these areas and, therefore, increases flood peaks in other locations. Traditionally, the measures undertaken to protect these potential damage centers have been structural (flood control reservoirs, dikes, etc.) in which the objective was to keep flood waters away from developments within the flood plain. In recent years, more emphasis has been placed on techniques which are designed to discourage development in flood-prone areas and even to relocate existing developments in some instances.

Recent concern for the decline of agriculture in the Connecticut River Basin is also a matter which has some relevance to flood plain management. Agricultural lands, forests and lands at various stages of succession between the former and the latter are generally considered compatible uses within the flood plain. Some of the best agricultural lands in the Connecticut River Basin are located in the flood plains.

It should be emphasized that suggesting remedies to halt the decline of agricultural land is not the primary objective of this report. This decline is a much broader problem than can be adequately handled within the context of a flood plain management study. In this report, it will be possible to assess only the effects of specific flood plain management alternatives relative to their probable effects on agriculture and other forms of land use.

Procedure

As previously mentioned, it was necessary to confine this study to the flood plains of the Connecticut River including the lower Deerfield River, the Westfield River and the Mill River. The entire study area is located within the state of Massachusetts.

The initial step was to define the relevant flood plains of these rivers. The determination on what to include as flood plain was based on existing information prepared for the Connecticut River Basin Comprehensive Survey. 1/ For the main stem of the Connecticut River and the Westfield River, the Standard Project Flood concept was employed. The 100-year

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1/ Comprehensive water and related land resource investigations, Connecticut River Basin, Appendix M, 1970.

flood definition (a flood which has the probability of occurrence of .01 in any given year) was used to determine the flood plain in the Mill River.

Flood-prone areas along the mainstream of the Connecticut River (including a portion of the Deerfield River) and the two tributaries were delineated on USGS quad sheets (1:24000 scale) according to flood stage data 1/ provided by the Corps of Engineers. To estimate acres of land use and land use change within the study area required that areal estimates be developed from maps prepared at the University of Massachusetts 2/ for 1951-52 and 1971-72. Initial attempts to digitize these maps and process the data were too time consuming due to the necessity of hand digitizing the data. An alternative method based on a stratified systematic unaligned point sampling procedure was then employed. 3/

To sample the study area on each quad sheet, a grid overlay on clear acetate was prepared on the Cal-Comp Plotter. A grid cell for the 1:24000 scale maps (1972) was 0.25 square inches (0.5 inches x 0.5 inches) or approximately 23 acres in size. The sample point within each grid cell was designated by generating random coordinates in the manner described by Berry. The advantages in producing this grid on the Cal-Comp Plotter were:

(1) the elimination of human drafting error, especially in locating and plotting points based on random coordinates, and

(2) the ability to replicate a sampling grid for maps at different map scales (1972 land uses are mapped at 1:24000 scale, whereas 1952 base maps were at 1:31680 scale).

This last procedure allowed sample points to be paired; for each point location on the 1972 land use maps, the same point location was identified on the 1952 maps. The exact replication of points on the 1952 maps was subject only to error in the original maps and slight differences in land use boundaries between the two periods. 4/

1/ See footnote 1/ on page 1.
2/ MacConnell, William P., et al. Department of Forestry and Wildlife Management. University of Massachusetts.
3/ Berry, B.J.L., 1962. "Sampling, Coding, and Storing Flood Plain Data." Agriculture Handbook No. 237, USDA.
A figure which explains this sampling procedure is reproduced in Appendix B.
4/ During the initial stages of data collection, a lack of comparable precision between 1952 and 1972 in the identification of urban type boundaries was noted. In order to account for any error this might introduce, an adjustment procedure was also employed. This adjustment was made by blocking the highly improbable reversion of urban land for 1952 into rural or non-developed categories for 1972. These improbable reversions were forced into the "urban open" category for 1972; this latter type is therefore over-estimated in the adjusted, disaggregated estimates for 1972. Such adjusted figures occur only in Table 6.

Definition of the land use categories for the two periods are provided in Appendix A. These are arranged to show the manner in which 1972 land use categories were aggregated to make them comparable to the 1952 categories.

The actual sampling procedure for each quad sheet was repeated four times, the overlay grid being randomly oriented for each sample. Each coded sample was processed by a simple computer program which accumulated counts of points, identifying for each point the associated 1972 land use, 1952 land use, town, and sample number. The mean and 95% confidence interval about this mean were derived by averaging over the four samples. Areas were then estimated on the basis of one sample point per 22.96 acres, this being established by the selection of the grid size.

In order to judge the likelihood of actual change during the 20-year period, the difference (1972-1952) for each of the five common categories was determined for each sample. Based on the estimated mean and variance of this difference statistic for each of the five categories, a T-value was computed. Comparison with statistical tables for T with 3 degrees of freedom allows a judgement to be made concerning the probability of actual change during the 20-year period.

Land use estimates were made for that portion of the main stem of the Connecticut River in Massachusetts and for the Mill and Westfield Rivers using the procedure described in the previous section. Since a sampling technique was employed, the point estimates of the mean acreage are presented with a confidence interval. This interval provided a range in acres within which it can be stated that there is 95 percent probability that the true acreage lies. For example, the mean acreage of tilled agricultural land in the Connecticut River Flood Plain in Franklin County is listed as 5,533 acres (Table 1). This is a point estimate that is unlikely to be exactly equal to the true acreage of tilled agricultural land in the designated area. However, by applying the $\pm$294 to mean figure it can be stated that there is a 95 percent probability that the actual number of acres of tilled agricultural land in the Franklin County portion of the flood plain lies between 5,239 acres and 5,827 acres.

Information on land use within proposed reservoir sites was provided by other agencies. Data on the Corps of Engineers Meadow Reservoir Site on the Deerfield River were provided by the Forest Service. 1/ The land-use data for the proposed PL566 reservoirs on the Mill River were provided by the Soil Conservation Service. 2/

1/ USDA - Forest Service, Portsmouth, N.H.
2/ USDA - Soil Conservation Service, Durham, NH

Table 1--Current land use in the floodplains of the Connecticut (including lower Deerfield River), Westfield, and Mill River in Massachusetts, 1972

	Franklin Co.		Hampshire Co.		Hampden Co.		Total Study Area	
	Mean acres	95% Confidence Interval	Mean acres	95% Confidence Interval	Mean acres	95% Confidence Interval	Mean acres	95% Confidence Interval
Tilled Agriculture 1/	5533	± 294	7186	± 344	1773	± 86	14492	± 460
Pasture	333	± 76	184	± 108	298	± 108	815	± 236
Industrial	52	± 18	121	± 18	1291	± 109	1464	± 105
Commercial	115	± 73	327	± 69	1366	± 92	1808	± 162
Residential	608	± 114	941	± 108	2737	± 147	4287	± 156
Other Urban 2/	57	± 21	80	± 47	522	± 162	660	± 210
Recreation	80	± 63	143	± 18	482	± 181	706	± 250
Water	3053	± 300	2640	± 143	3312	± 297	9005	± 91
Wetland	224	± 75	344	± 67	57	± 21	626	± 75
Forest	2072	± 185	2927	± 218	3042	± 185	8041	± 337
Abandoned Land Types 3/	396	± 55	436	± 176	1194	± 108	2026	± 164
Totals	12523	± 92	15329	± 175	16076	± 164	43928	± 323

1/ Estimate includes less than 35 acres of orchard in Hampden County only

2/ Other urban includes institutional, urban open, and extraction and waste

3/ Estimate includes unused tillable land

CURRENT LAND USE

While forest is the predominant form of land use in the Connecticut River Basin, this is not the case for the flood plains of the Connecticut River and its major tributaries within the Commonwealth of Massachusetts. Tilled agriculture is the leading form of land use within these flood plains, accounting for over 30 percent of the total area. In terms of the confidence interval, it can be stated that a 95 percent probability exists that the acres of tilled agricultural land in these flood plains lie between 14,033 acres and 14,927 acres. The portions of the Connecticut River flood plains in both Franklin and Hampshire counties have over 40 percent of their land area in the tilled agricultural category, while the Hampden County portion of the flood plain has slightly over 10 percent. Other agricultural land uses such as pasture, orchards, and nurseries are not widespread in the flood plain.

Urban use of the flood plain is most common in Hampden County, which contains the cities of Springfield, West Springfield, Holyoke and Chicopee. Nearly 40 percent of the flood plains in Hampden County are in some form of urban usage. By contrast, urban use of the flood plains in Hampshire and Franklin Counties is near 12 to 9 percent respectively. In Hampden County, flood plain development for industrial, commercial, high density residential, and medium density residential purposes is common. Conversely, low density residential areas are the major form of urban development in Hampshire and Franklin Counties.

Forests are another major component of the flood plains of the Connecticut River, although accounting for less than 20 percent of the land in all three counties. Lands which have been abandoned from active pursuits do not exist in sufficient quantities so that any major reversion to forests can be expected in the near future.

Since the river surface is included in the total area, water accounts for about one-fifth of the area. At the 95 percent confidence level, there is between 8914 and 9096 acres of water surface included in the flood plains of the Connecticut River and its major tributaries in Massachusetts.

Main Stem

Since the flood plain of the main stem of the Connecticut River dominates the total study area, it is not surprising that the proportions of land use for the former is quite similar to the latter. Of the 43,928 acres of flood plains included in the study, 37,965 are in the main stem of the Connecticut River which also includes the lower Deerfield River in Franklin County. The flood plains of the Connecticut River also include portions of the lower Westfield and Mill River flood plains which would be affected by floods of the main stem. These common areas are not included in the data for the tributaries.

Most of the tilled agricultural lands in the study area are located in the flood plains of the main stem (Table 2). This is estimated to be between 13,703 and 14,927 acres at the 95 percent confidence level. Hampshire and Franklin Counties contain most of these agricultural lands.

Table 2--Current land use in the Massachusetts portion of the Connecticut River floodplain including lower Deerfield River, 1972

	Franklin Co.		Hampshire Co.		Hampden Co.		Total Study Area	
	Mean acres	95% Confidence Interval	Mean acres	95% Confidence Interval	Mean acres	95% Confidence Interval	Mean acres	95% Confidence Interval
Tilled Agriculture 1/	5533	± 294	7019	± 346	568	± 62	13120	± 501
Pasture	333	± 76	184	± 108	92	± 42	608	± 210
Industrial	52	± 18	80	± 47	1050	± 101	1182	± 63
Commercial	115	± 73	327	± 69	1079	± 133	1521	± 121
Residential	608	± 114	895	± 52	2009	± 192	3512	± 90
Other Urban 2/	57	± 21	80	± 47	453	± 138	591	± 185
Recreation	80	± 63	92	± 0	315	± 109	488	± 167
Water	3053	± 300	2514	± 190	2812	± 220	8379	± 237
Wetland	224	± 75	344	± 67	52	± 35	620	± 79
Forest	2072	± 185	2554	± 113	1653	± 219	6279	± 346
Abandoned Land Types 3/	396	± 55	413	± 184	855	± 91	1664	± 128
Totals	12523	± 92	14503	± 124	10939	± 138	37965	± 237

1/ Estimate includes less than 35 acres of orchard in Hampden County only

2/ Other urban includes institutional, urban open, and extraction and waste

3/ Estimate includes unused tillable land

Other land uses follow the same patterns along the flood plains of the main stem as for the total study area. Urban uses make up about the same proportion of total land use and are most concentrated in Hampden County. Forest and water cover are the other major land-use categories.

Westfield River

The entire flood plain of that portion of the Westfield River included in the study area is located in Hampden County and is similar to that county's portion of the main stem in that much of the flood plain has been developed into urban uses (Table 3). Of the 5,137 acres in the Westfield Flood Plains, it is estimated that between 1352 and 1632 acres (95 percent probability) are in urban uses. The most prevalent urban uses in this flood plain are medium density residential, commercial, and industrial.

Agriculture is another major use of the flood plain of the Westfield River. At the 95 percent confidence level, the estimated acreage of tilled agricultural land falls between 876 acres and 1086 acres. There is also a very limited acreage of pasture in this flood plain.

Forests cover over twenty-five percent of the Westfield River Flood Plain. The limited amount of abandoned land types suggests that the proportion of forest land is not likely to increase substantially in the near future.

Mill River

Due to the limited size of the Mill River Flood Plain, it was necessary to aggregate the land-use categories in order to obtain meaningful information (Table 4). Forests appear to be the predominant form of land cover in this flood plain with between 252 and 494 acres at the 95 percent confidence level. Agricultural lands account for about one-fifth of the total land area. Two land-use categories, urban and "water and wet lands" have such high confidence intervals that it is difficult to make any useful interpretations.

Table 4--Current land use in the flood plains of the Mill River, 1972

	Mean acres	95% Confidence Interval
Agriculture 1/	166	± 18
Urban	138	± 67
Water and wetlands	126	± 92
Forests	373	±121
Abandoned land types 2/	23	± 30
Totals	826	± 52

1/ Agriculture includes only tilled land and pasture in this subarea.
2/ Unused tillable land was not present in the estimates for this subarea.

Table 3--Current land use in the floodplain of the Westfield River, Massachusetts, 1972 1/

Land use category	Acres of land	
	Mean	95% Confidence Interval
Tilled agriculture 2/	1205	± 87
Pasture	207	± 79
Industrial	287	± 92
Commercial	729	± 96
Residential	729	± 96
Other Urban 3/	69	± 30
Recreation	166	± 75
Water	499	± 91
Wetland	6	± 18
Forest	1389	± 114
Abandoned land types 4/	339	± 117
Totals	5137	± 257

1/ Does not include land area which is common with that already tabulated as part of the main stem of the Connecticut River floodplain.

2/ Estimate includes less than 35 acres of orchard in Hampden County only.

3/ Other urban includes institutional, urban open, and extraction and waste.

4/ Estimate includes unused tillable land.

LAND USE CHANGES

In order to gain more reliable information on land-use changes from 1952 to 1972, the flood plains of the main stem of the Connecticut, the Westfield and the Mill Rivers were considered as a unit (Table 5). For this entire area, significant changes at the .99 level were found for the agriculture, urban, "water and wetlands" and forest categories. The remaining category, abandoned land types, was not significant, even at the .90 level. Of the categories which showed significant changes in acreage over this time period, agriculture and "water and wetlands" declined while urban and forest increased.

The Franklin County portion of the Connecticut River Flood Plain, which also includes the lower Deerfield River Flood Plain, experienced land use changes which varied somewhat from those of the total area. Significant changes at the .98 level were found in all land use changes except "water and wetlands." Declines were noted in agriculture and abandoned land types, but forest and urban lands increased as was the case for the total area.

In the Hampshire County subarea, which includes the Mill River Flood Plain as well as that portion of the main stem of the Connecticut in the county, land use changed in a manner similar to the total area. The urban and forest categories experienced significant increases in acreage at the .98 level of significance. Acreages in agriculture and "water and wetlands" declined at the .98 level. Changes in the abandoned land types were not found to be significant.

The Hampden county subarea including the lower portion of the main stem in Massachusetts and the Westfield River had significant changes in the land use at the .99 level for three categories. These were agriculture, "water and wetlands," and urban. Only the latter of these increased in acreage from 1952 to 1972.

It is noteworthy that acres of agricultural land decreased significantly in all subareas. This is consistant with the trends of land use throughout the Connecticut River Basin.

Perhaps of greater concern than the loss of agricultural lands in the flood plains of the Connecticut River and its major tributaries in Massachusetts is the increase in urban development in these areas. While changes of agriculture land to forest or abandoned land-use types do not reduce the natural flood storage capacities of flood plains, urban development can reduce this capacity as well as increase the potential for flood damages. Current estimates based on the sample data indicate that nearly 20 percent of these flood plains are presently occupied by urban development, much of this occurring in Hampden County. When adjustments were made in the techniques employed to allow for mapping differences between 1952 and 1972, 1/ increases were indicated for both the proportion of

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1/ See footnote 4, on page 2.

Table 5--Estimates of land use in the floodplains of the Connecticut, Westfield, and Mill Rivers for 1952 and 1972 1/

Subareas and Flood Plains included	Land use category	1952 Mean acres	1952 95% Confidence interval	1972 Mean acres	1972 95% Confidence interval	Change in mean acres 1972-1952	Computed T value (D.F.=3)
Total Area	Agriculture	18,228	± 647	15,307	± 603	-2,921	-30.221
Connecticut River	Urban	6,462	± 135	8,924	± 347	2,462	27.945
(including Deerfield River)	Water & wetlands	10,560	± 493	9,630	± 105	- 930	- 6.681
Westfield River	Forest	6,692	± 857	8,041	± 337	1,349	6.621
Mill River	Abandoned land	1,986	± 448	2,026	± 164	40	0.248
	Total	43,928	± 323	43,928	± 323		
Franklin County	Agriculture	6,302	± 346	5,865	± 363	- 437	- 6.649
Connecticut River	Urban	442	± 81	912	± 109	471	13.187
(including Deerfield	Water & wetlands	3,306	± 275	3,277	± 337	- 29	- 0.326
River)	Forest	1,802	± 341	2,072	± 185	290	4.909
	Abandoned land	671	± 96	396	± 55	- 275	- 9.295
	Total	12,523	± 92	12,523	± 92		
Hampshire County	Agriculture	8,557	± 239	7,369	± 333	-1,188	-28.798
Connecticut River	Urban	855	± 138	1,612	± 105	758	15.853
Mill River	Water & wetlands	3,501	± 487	2,984	± 166	- 516	- 4.770
	Forest	2,055	± 346	2,927	± 218	872	11.206
	Abandoned land	362	± 175	436	± 176	74	1.809
	Total	15,329	± 175	15,329	± 175		
Hampden County	Agriculture	3,369	± 226	2,072	± 147	-1,297	-17.232
Connecticut River	Urban	5,165	± 108	6,399	± 180	1,234	19.128
Westfield River	Water & wetlands	3,753	± 240	3,369	± 288	- 384	- 8.874
	Forest	2,835	± 290	3,042	± 185	207	1.912
	Abandoned land	953	± 346	1,193	± 108	240	1.694
	Total	16,076	± 164	16,076	± 164		

1/ See footnote 4, page 2.

land in urban category and the rate of increase between 1952 and 1972 (Table 6.)

The increase in forested land over this 20-year period can be attributed to the reversion of lands which had previously been abandoned from agricultural pursuits. Forests are considered a desirable flood plain use in that they not only permit natural storage, but tend to reduce the velocity of flood waters in some instances.

PROPOSED MANAGEMENT ALTERNATIVES

Having estimated current land use and the changes that have occured over a 20-year period in the flood plains of the Connecticut River and its tributaries in Massachusetts, the task is now to examine specific flood plain management alternatives and to assess their likely effects on land use. The types of land use changes that were found to be occurring in the flood plains have been recognized, if not documented, by both public officials and interested citizens. Expressions of concern over such matters as the loss of wetlands, the decline of agricultural land use, and the development of flood-prone areas have come from many sources. Although the Connecticut River Basin Supplemental Study is primarily concerned with flood plain management primarily as a means of reducing future flood losses, its programs are also likely to affect other aspects of land use. Both structural and non-structural measures are being considered in the Supplemental Study.

Structural Measures 1/

For the main stem of the Connecticut River, two structural and one non-structural alternatives are being considered to provide protection to the critical flood-prone areas. Alternative I involves the construction of seven additional flood-control dams. However, only one of these, the Meadow site, is located in Massachusetts. The other six flood control reservoir sites are located in New Hampshire and Vermont.

The other means of structurally providing protection up to the standard project flood level (Alternative II) is through raising the already existing dikes in five Massachusetts communities along the Connecticut River. Under this approach, dikes would also have to be raised in East Hartford, Connecticut.

In addition to the consideration of structural measures to provide flood protection along the main stem, three smaller reservoirs are being evaluated as a means to provide local protection along the Mill River. The land use implications of these proposals are discussed in the following subsections.

Meadow Reservoir. The Meadow Reservoir site, which is located on the Deerfield River, involves four Massachusetts towns: Buckland, Conway, Deerfield,

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1/ For a more complete description of the flood plain management alternatives being considered in the Connecticut River Basin Supplemental Study, see footnote 1, page 1.

Table 6--Estimates of land use in the floodplains of the Connecticut, Westfield, and Mill Rivers for 1952 and 1972 with adjustments 1/

Subareas and Flood Plains included	Land use category	1952 Mean acres	1952 95% Confidence interval	1972 Mean acres	1972 95% Confidence interval	Change in mean acres 1972-1952	Computed T value (D.F.=3)
Total Area	Agriculture	18,228	± 647	15,048	± 672	-3,180	-36.062
Connecticut River	Urban	6,462	± 135	9,981	± 285	3,518	59.823
(including Deerfield River)	Water & wetlands	10,560	± 493	9,366	± 158	-1,194	- 9.740
Westfield River	Forest	6,692	± 857	7,719	± 431	1,027	5.431
Mill River	Abandoned land	1,986	± 448	1,814	± 193	- 172	- 1.080
	Total	43,928	± 323	43,928	± 323		
Franklin County	Agriculture	6,302	± 346	5,802	± 343	- 500	- 8.834
Connecticut River	Urban	442	± 81	1,096	± 46	654	19.745
(including Deerfield	Water & wetlands	3,306	± 275	3,243	± 323	- 63	- 0.721
River)	Forest	1,802	± 341	2,015	± 147	212	3.258
	Abandoned land	671	± 96	367	± 52	- 304	-10.076
	Total	12,523	± 92	12,523	± 92		
Hampshire County	Agriculture	8,557	± 239	7,220	± 389	-1,337	-23.339
Connecticut River	Ubran	855	± 138	1,860	± 155	1,004	30.464
Mill River	Water & wetlands	3,501	± 487	2,964	± 153	- 534	- 4.877
	Forest	2,055	± 346	2,858	± 218	804	10.321
	Abandoned land	362	± 175	425	± 170	63	1.777
	Total	15,329	± 175	15,329	± 175		
Hampden County	Agriculture	3,369	± 226	2,026	± 128	-1,343	-18.735
Connecticut River	Urban	5,165	± 108	7,025	± 123	1,860	38.911
Westfield River	Water & wetlands	3,753	± 240	3,157	± 271	- 597	-24.071
	Forest	2,835	± 290	2,847	± 179	11	0.146
	Abandoned land	953	± 346	1,022	± 114	69	0.499
	Total	16,076	± 164	16,076	± 164		

1/ See footnote 4, page 2.

and Shelbourne. As presently conceived, this will be a dry-bed flood control reservoir. Of the seven proposed reservoirs, the meadow is expected to have the greatest impact on reducing flood peaks in the lower reaches of the Basin.

Over seventy percent of the land that would be inundated if the reservoir were filled to capacity 1/ is presently forested (Table 7). The area has limited residential, commercial, and light industrial acreages. Agriculture accounts for less than seven percent of the reservoir area. This is principally cropland, but also includes some pasture and orchard. An examination of old aerial photographs reveals the area had been more heavily farmed in the past, but has principally reverted to forest.

The construction of this dam would not necessarily cause severe land use change in the reservoir area. Both agricultural and forest land uses can withstand occasional flooding without serious detrimental affects. Most of the agricultural land located in the reservoir site is located on the outer margins so it should be subject to infrequent flooding. Therefore, it appears feasible to continue agricultural pursuits on these lands if the necessary provisions are undertaken to permit such activity.

Those forested areas located on lower elevations where annual inundation might be expected should experience changes in species association over time, but little affect is expected for forests subject to infrequent inundation.

No attempt was made to assess the effects of the construction on agriculture in downstream areas. Obviously, the reservoir would protect some cropland and pasture from flooding, but would also make these areas more desirable for competitive uses. On the other hand, low-lying areas in agricultural production might be subjected to longer periods of inundation due to the gradual release of stored waters from the reservoir.

Raising Dikes Along Main Stem. As a structural alternative to the seven upstream flood control reservoirs, raising existing dikes to provide protection up to the standard project flood level is being considered. Within Massachusetts, this would involve raising the existing dikes in Northampton, Holyoke, Chicopee, West Springfield and Springfield.

While detailed land use figures are not available for the protected areas behind these dikes, it is unlikely that raising them will have much effect on agricultural land use. The areas behind these dikes must be well developed to justify such construction in the first place. While raising the dikes will reduce the probability of flood damages, it is uncertain as to what extent the difference in risk between the current level of protection and the standard project flood level might have on potential developers.

1/ See footnote 1/ on page 7.

Table 7. Present Land Use in the Meadow Reservoir Site. 1/

Land Use Category	Area in Acres	Percent of Total
Agriculture	140	6.7
Wetland	25	1.2
Water	247	11.9
Forest	1,482	71.1
Industrial and Commercial	29	1.4
Residential	16	0.8
Other	144	6.9
	2,083	100%

1/ Information provided by USDA - Forest Service, Portsmouth, NH

The raising of these dikes should not have any measurable effects on land use in non-protected areas of the flood plain. While the protection provided by such structures reduces the natural storage capability of the flood plain and therefore, may cause increases in peak flows elsewhere, the probability of such an event occuring due to the raising of already existing dikes is probably too remote to have a meaningful influence on land use changes. Since the existing dikes provide protection up to a probability of occurrence of less than one year in a hundred, the risk of greater inundation in non-protected portions of the flood plain brought about by the raising of these dikes would be even more remote. Once again, the only floods that would be relevant are those where the intensity was between the current level of protection and that necessary to withstand a standard project flood.

Mill River. 1/ Two plans are being evaluated to provide flood protection along the Mill River, one is completely nonstructural and the other involves the construction of three reservoirs under the PL566 Program. The latter approach also includes several nonstructural elements such as land use regulations, floodproofing, flood insurance and a flood warning and evacuation plan.

1/ Information provided by USDA-SCS, Durham, NH

In total, the three proposed reservoir sites include 580 acres of land and eight homes. Land use in the proposed sites is primarily forest and other undeveloped land including an estimated 145 acres in agriculture. According to Soil Conservation Service estimates, about five acres of this agricultural land would be lost to other uses if the dry-bed reservoirs were constructed. As previously mentioned, occasionally flooded lands can remain in agriculture with relatively minor losses in productivity if provisions for their continued use for such purposes are made.

Nonstructural Measures

All of the flood management plans (including those that emphasize structural measures) being considered in the Supplemental Study contain nonstructural elements. Even the baseline or "no plan" alternative includes those nonstructural measures which are currently in existence and those which are expected to be operative by the time the Supplemental Study program is implemented. There are three nonstructural programs being considered for the main stem of the Connecticut River, in addition to the baseline. These are designated as Programs A, B, and C. 1/ Beside the baseline, two alternatives were considered for the Mill River: Plan I which contains structural elements and Plan 4 which includes structural as well as nonstructural measures.

The baseline alternative will contain elements designed to prevent the increase of potential damage and maintain natural storage within the flood plain of intermediate regional floods. While the baseline includes several federal, state and local flood plain management elements, its principal component is the provisions of the Flood Disaster Protection Act of 1973. 2/ The intent of this act is to make flood insurance available to flood plain occupants in qualifying communities, and it also requires that these communities take certain measures designed to discourage the increase of potential damage within the intermediate regional flood plain. Under provisions of the Act, insurance premium rates are subsidized for existing buildings within the flood plain, but actuarial premium rates will be charged for any new construction or existing buildings undergoing substantial improvements after the Federal Insurance Administration has delineated the flood hazard area. Property owners within designated flood hazard areas who do not purchase insurance, once it becomes available to their community, will not be eligible for any new or additional Federal or federally-related financial assistance or credit for any buildings located within such areas.

1/ Cheney, Miller, Ellis & Assoc., Inc., Nonstructural Measures for Flood Plain and Flood Damage Management, February 1974.

2/ Flood Disaster Protection Act of 1973 Public Law 93-234, 93rd Congress, December 31, 1973.

In order to qualify for flood damage insurance, a community must meet minimal standards in terms of discouraging the growth of damage potential within designated flood plain areas. Communities are required to implement and enforce land control measures designed to prevent future flood susceptible development in danger areas. Initially, the adoption of building permit systems will be sufficient for communities which do not have them. The Act does not intend to prevent all flood plain development, but to discourage any development that would increase the flood hazard. New construction which is properly elevated or otherwise flood-proofed can qualify for insurance rates which are not significantly higher than the subsidized rates.

Besides the provisions of the Flood Disaster Protection Act, the baseline alternative includes a flood warning system (partially operative at this time) and an evacuation system. Those state and local flood plain management controls presently in existence are also part of the baseline alternative.

While Alternatives 1 and 2 contained structural elements, Alternative 3 represents a completely nonstructural approach to flood management.

Programs A and B not only attempt to maintain natural storage and prevent increasing damages, but attempt to reduce existing damages. Program B, the maximum nonstructural Program, is designed to prevent increasing damages and reduce existing damages up to the standard project flood level. Program A attempts to prevent increasing damage to the same level, but tries to reduce existing damages to only the intermediate regional flood level.

Program C is designed to provide a lower degree of flood damage reduction and is more flexible than the other two programs. It includes a wider range of options for local communities and individuals relative to flood plain management.

Each of these programs contain essentially the same elements, differing only in the intensity to which they should be applied. All programs include the provisions of the baseline or no plan alternative. The imposition of land use regulations is suggested as a means to prevent further development of flood-prone areas. In some instances, public acquisition is recommended. Flood-proofing of existing buildings will be done, when feasible, and in more extreme situations, relocation of such buildings is suggested. These measures will be detailed in the following subsection which attempts to assess their probable effects on land use within the flood plain.

Effects on Agricultural Land Use. It is particularly difficult to assess the effects of proposed nonstructural measures on agricultural land use in the flood plains since many other factors are involved. Even if programs are implemented that effectively reduce competition for lands utilized for agricultural purposes, there is no assurance that this use

will remain viable. As indicated in the Phase I Report, 1/ there are five major factors that are responsible for the decline of agriculture in the Connecticut River Basin. Competition for land is just one of these factors; the others are change in the technology of agricultural production, interregional competition, competition for human resources, and high property taxes.

In terms of floodplain management, agriculture is considered a compatible use for flood-prone areas but other types of land use such as forests or open reverting lands are considered equally desirable if not preferable. Croplands are generally subject to greater damages from flooding than are forests or grasslands. Nevertheless, the use of flood-prone lands for agricultural purposes retains the natural storage capacities of these areas while permitting the production of crops. The various measures being considered in the Supplemental Study are likely to affect land use within the flood plains, but it is less certain as to what measurable effects they are likely to have on agriculture.

The National Flood Insurance Program is apt to have both direct and indirect effects on land use within the flood plains. Any subsidization of flood insurance premium rates for flood-prone areas will reduce the risks of construction on such areas and, thus, make development relatively more attractive. On the other hand, charging actuarial rates should have the effect of discouraging development on areas in accordance with their flood risk. The provisions denying Federal or federal-related financial assistance to individuals or communities not entering the program should also discourage the development of flood hazard areas.

As for the provisions of the Act which are designed to persuade communities to discourage development on flood danger areas, these should favor agriculture. Prohibiting construction or increasing the cost of construction by requiring flood proofing or other safeguards would tend to reduce the market value of land in such areas and, therefore, also reduce property tax assessments. While making developmental alternatives less competitive for land does not assure that such lands will be used for agriculture, it does increase the likelihood that they will be retained in uses compatible with natural storage and effect a control on the growth of flood damage potential.

The institution of an effective flood warning system and evacuation plan could act to diminish the amount of agricultural and other low damage potential uses within flood-prone areas. Such a system would reduce the risk of flood losses and, there, make certain types of land development more competitive for land. Of course, such systems are designed to reduce losses being carried out in flood hazard areas.

1/ Glass, R.J., THE RIVER'S REACH Phase I - SOME ENVIRONMENTAL AND FLOOD PLAIN MANAGEMENT IMPLICATIONS OF THE CHANGING ROLE OF AGRICULTURE, Connecticut River Basin Supplemental Study, USDA-ERS, March, 1974.

Flood plain zoning can encourage agriculture and other open space uses by prohibiting specific types of development on flood susceptible areas. With fewer uses permitted, competition for land should decrease and make agriculture relatively more attractive. Since land competition seems to be just one of several factors which appear to be responsible for the decline of agriculture in the Connecticut River Basin, there is no assurance that the prohibition of specific flood plain uses will result in more agricultural land use or even retain that which exists today. However, it should encourage the retention of lands in other uses compatible with the flood plain management objectives of the Supplemental Study.

Public acquisition is the surest way to retain flood-prone lands in desired uses. Acquisition can be made in fee simple or development rights can be purchased. In the former case, it would be possible to lease such lands to farmers so that they can be used for agricultural purposes. If development rights are purchased, landowners may continue to practice agriculture with little competition for other uses and lower property tax assessments. Once again, these approaches merely make agriculture a more competitive land use by eliminating certain alternatives but do not in any way assure that such lands will be utilized for agricultural purposes. They do make certain that such areas are retained for natural storage and that the growth in damage potential can be controlled.

Where existing buildings are relocated out of the flood plain or purchased to be demolished, land which had a high damage potential because of its degree of development is put into other uses, one of which may be agriculture. Here again, suitable leasing arrangements must be made with willing farmers if agriculture is to be practiced on such lands. Considering the amount of land which has been abandoned from agricultural pursuits, land scarcity does not seem to be a major cause of the decline of agriculture.

While five factors considered responsible for the decline of agriculture in the Connecticut River Basin were defined in the Phase I Report of the Economic Research Service, the flood plain management measures suggested in the Supplemental Study appear to affect only one of these, competition for land. The recent enactment of legislation in Massachusetts which permits agricultural lands to be assessed relative to current use rather than market value may help reduce the property tax load on farms. The effectiveness of this program will have to be scrutinized over the next several years. Even if these measures are effective in diminishing land competition in the flood plains and reducing property taxes on these lands, there are still three major factors that may cause a further decline in agricultural land use. Changes in the technology of agricultural production, particularly for dairying, make it possible to maintain current production, or even increase it, on less land. Agriculture in the Basin must still compete with other regions, many of which are more generously endowed with natural resources. In this region, which is predominated by the nonagricultural sectors of the economy, competition for human resources is another major factor responsible for the decline of agriculture. Only time will tell if the measures recommended in the Supplemental Study, the attempt to alleviate some of the property tax load on agricultural lands, and changing marketing conditions for many agricultural products will effectively outweigh the negative factors and stabilize the amount

of land in flood plains utilized for agricultural purposes. Whether or not this occurs, these measures should be effective in reducing development in flood plains and thus retaining natural storage while slowing the growth of damage potential. The degree to which such land will be used for agriculture may be uncertain, but it is likely to remain in other use consistent with the objectives of the Supplemental Study.

SUMMARY AND CONCLUSIONS

Land use in flood-prone areas is a matter of particular concern to water resource planners. Agriculture is considered a compatible use of flood plains; but forests and abandoned lands are equally desirable to maintain natural storage capacities and in preventing increases in potential damages. Development of flood plains by man-made structures tend to reduce natural storage capabilities and increases the potential for flood losses.

Due to budgetary limitations, this study concentrated on the Massachusetts portion of the Connecticut River. Flood plains up to the standard project flood level were delineated on USGS quad sheets for the main stem of the Connecticut River and the Westfield River. The same procedure was used for the Mill River, but only to the Intermediate Regional Flood level. A sampling technique was employed on maps prepared at the University of Massachusetts to estimate 1952 and 1972 land use in the specified flood plains. For the combined flood plains of the Connecticut, Westfield and Mill Rivers, tilled agriculture is the leading land use. Agricultural lands comprise over 40 percent of the total land area in the flood plains of Franklin and Hampshire Counties. In Hampden County, where the flood plains are most heavily urbanized, agriculture accounts for only slightly over 10 percent of the land use. Besides agriculture and urban, the other major land uses in these flood plains are forests and "water and wetlands."

Since the main stem of the Connecticut River accounts for 86 percent of the area studied, it is not surprising that its specified land uses are similar to the total area. The flood plains of the Westfield River are relatively heavily urbanized as is that portion of the main stem in Hampden County. Agriculture and forests are other major land uses of the Westfield River Flood Plain. Due to the limited area sampled, the land use estimates for the Mill River are rather inconclusive.

In the flood plains of the Connecticut River and its tributaries in Massachusetts, significant declines at the .99 level were found to have occurred from 1952 to 1972 for the agriculture and "water and wetlands" categories. Significant increases at the same level were experienced for forest and urban land uses. Some differences in the categories of land use which underwent statistically significant changes were noted for the county subareas of the flood plains. It is noteworthy that significant declines in agriculture and significant increases in urban development occurred at the .98 confidence level in all county subareas.

Having examined current land use in the flood plains and the changes that had occurred over a 20-year period, ERS was also assigned the responsibility of assessing the effects of proposed flood plain management alternatives on future land use with particular emphasis on agriculture.

An examination of land use that would be directly affected by the proposed structural measures indicated that such structures would not have much effect on current land use. By contrast, several nonstructural measures could do much to discourage further urban development on flood plains and thus retain them in "compatible" uses.

The flood plain management alternatives being considered in the supplemental study were not specifically designed to maintain agricultural use of the flood plains and there is considerable uncertainty as to how effective they will be toward this end. Policies which restrict urban development in flood plains or make it more costly will have the tendency of reducing land competition and, therefore, create a situation more desirable for extensive land uses. Whether or not such lands remain in agricultural production or are permitted to revert to forests will be determined by a number of factors, land competition being just one of these.

Appendix A: Definition of Land Use Categories

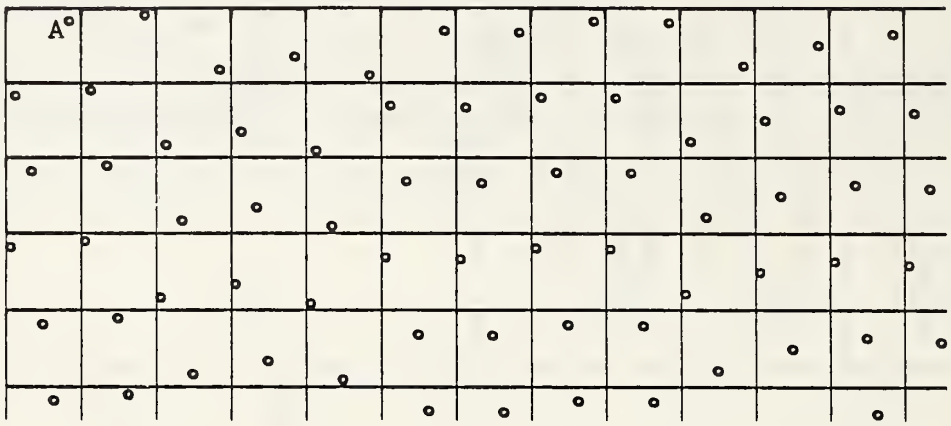
1972					1952	
Code[1]	MacConnell's Codes	Land use types identified on 1972 maps		Common aggregation[2]	Code[1]	MacConnell's Codes
00		Non-Study Area			00	
11	T	Tilled	Tilled land	Agriculture and Open lands	04	AL, AL-M, AL-I
14	O, N	Orchard and Nursery	Tilled land	Agriculture and Open lands	04	CB, O
13	P	Pasture	Tilled land	Agriculture and Open lands	04	AL, AL-M, AL-I
09	SF thru DSM, CB	Wetland		Wetlands and water	03	FM, SS, SFM, DFM
10	W	Water		Wetlands and water	03	SM, W
01	H1 thru H6, S1 thru S6, HS1 thru HS6, SH1 thru SH6, PS1 thru PS6	Forest		Forest	01	H1 thru H6, S1 thru S6, HS1 thru HS6, SH1 thru SH6
02	UI, UL	Industrial		Urban	02	U
03	UC, UH, US, UTA, UTW, UTR, UTT, HW	Commercial		Urban	02	U
04	UA, UT, URH	Residential high density	Residential	Urban	02	U
05	URM	Residential med. density	Residential	Urban	02	U
06	URL, URO, URF, UCR, UE	Residential low density	Residential	Urban	02	U
07	UP, +	Institutional	Other Urban	Urban	02	U
08	UO	Urban open	Other Urban	Urban	02	U
18	SG thru FB	Mining and waste disposal	Other Urban	Urban	02	U
16	RM, RS, RC, RT, RA, RAP, RFG, RI	Intensive recreation	Recreation	Urban	02	U
17	RFB, RSB, RG, RD, RPG, RSK, RP	Extensive recreation	Recreation	Urban	02	U
15	AF, AO, S, PL, H	Abandoned land	Abandoned agriculture	Abandoned fields and orchards	05	AO, AF, S
12	TU	Unused tillable	Abandoned agriculture	Abandoned fields and orchards	05	AO, AF, S

1/ Numerical codes are for those categories originally sampled

2/ Land use types identified on 1952 maps

Appendix B

Construction of a Stratified Systematic Unaligned Point Sample Grid



The point sampling grid illustrated above is a reproduction of a portion of the grid used to sample the 1:31680 scale maps. Such a grid is constructed in the following manner. First, the grid size is chosen to produce the desired sampling density. The X and Y coordinates of point A are then selected randomly. The remaining points in the first row are then located using the X coordinate of point A, incremented appropriately for each grid cell, together with randomly selected Y coordinates. The remaining points in the first column are similarly located using the Y coordinate of A together with randomly selected X coordinates. Other points in the grid are located using the randomly selected X coordinate from the appropriate cell in the first column and the randomly selected Y coordinate from the appropriate cell in the first row. The resulting sample grid combines the advantages of randomization and stratification with the useful aspects of systematic samples, while avoiding possibilities of bias because periodicities might be present.